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COMMENTS ON BISTATIC LIDAR

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In our discussions thus far, we have ignored, for the most part, the question of how effectively lidar can be employed to determine information about the sizes and concentrations of atmospheric aerosols. This is admittedly a difficult question to answer due to the complicated scattering problem which is encountered. But the question is quite relevant in view of the fact that lidar offers one of the most apparent remote probing techniques for studying the properties of aerosols. Some preliminary work on lidar measurements of aerosol distributions has already been attempted by Barrett and Ben-Dov (1967) by making use of backscattered lidar measurements. However, since light scattered by particulates depends on a number of scatterer properties, the amount of information which can be derived about the nature of the particles by measuring only the backscattered intensity of the scattered light is quite limited. It is therefore worthwhile to consider other experimental techniques which take greater advantage of the information available in the scattered signal. In this regard, I would like to comment on the possibility of using bistatic lidar systems.

Monostatic lidar is limited to measurements in only the backscattered direction. In contrast, bistatic lidar provides a means for measuring not only the intensity but also the polarization of light scattered at various angles other than 180° (backscattering). Bistatic lidar, therefore, presents a method for obtaining additional pieces of experimental information which can, in principle, be used to infer more about the size distribution and number density of aerosols than can be inferred from monostatic measurements. In particular, it appears that <u>elliptical</u> polarization measurements can be quite useful in this respect. For example, recent theoretical and experimental work presented by Eiden (1966) indicates that the ellipticity of angularly scattered light which is initially linearly polarized is quite sensitive to the size distribution and index of refraction of aerosol particles for wavelengths close to the typical lidar wavelength, 0.6943 microns (ruby). Moreover, measurements of the

ellipticity of scattered light can unambiguously be attributed to aerosols alone, since molecular scattering does not give rise to elliptical polarization of the scattered signal as long as we are dealing with single scattering. Polarization measurements are also advantageous in that the ellipticity of the received scattered signal can be obtained from the ratios of relative intensity components. This eliminates the difficult problem of having to make absolute intensity measurements. Also, lasers provide excellent linearly polarized sources.

I want to stress, however, that I am not suggesting that bistatic lidar can be used to uniquely determine the size distribution and number density of an arbitrary distribution of particulates. First of all, while bistatic lidar provides a means for obtaining several more measurements than can be made with a monostatic system, an unfeasibly large number of measurements would be required to completely determine the scatterer distribution. Secondly, as recently pointed out by Twomey and Howell (1967), the measurements must be made quite accurately, typically with an error of 1 percent or less, to obtain a few pieces of independent information about the scatterers. It appears, however, that bistatic measurements made at several scattering angles coupled with logical a priori assumptions about the general mathematical form of the particle size distribution can provide useful estimates about the distribution of particulates in the atmosphere. Moreover, through polarization measurements, it may be possible to distinguish certain meteorological phenomena which influence the vertical distribution of particulates; namely, variations in the temperature distribution which bring about a collection of particulates in the vicinity of stable layers and regions of high humidity which give rise to swelling in size of hygroscopic particles.

With regard to existing or planned bistatic lidar installations, I understand that Dr. Paul Palmer at Brigham Young University has assembled a system which became operational about a month before this meeting. Also, I am attempting to set up a bistatic system at the University of Arizona. At present, I am working with Dr. Benjamin Herman, University of Arizona, on a theoretical study to investigate the ambiguity involved in attempting to invert bistatic lidar measurements to infer information about the sizes and concentrations of particulates as a function of height. We hope to have an operational bistatic system for probing to heights of about 10 kilometers by the end of this year.

References

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3. Twomey, W. and H. B. Howell (1967), Some aspects of the optical estimation of microstructure in fog and cloud, App. Optics, 6, 2125-2131.

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Radar